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RESEARCH PAPER

ANALYSIS OF SELECTED NATURALLY OCCURRING ORGANIC FERTILIZERS BY INSTRUMENTAL NEUTRON ACTIVATION ANALYSIS USING THE NIGERIAN RESEARCH RECTOR-1(NIRR-1): THE QUEST FOR SAFER SOURCE OF PLANT NUTRIENTS

Jamok Jacob Elisha[1] and Martha Jamok Elisha[2]
[1] Centre for Biotechnology Research and Training, Ahmadu Bello University Zaria, Kaduna State Nigeria
[2]Kashim Ibrahim Library, Ahmadu Bello University, Zaria.

ABSTRACT

Elemental analysis of different naturally occurring organic fertilizers obtained from different farms in Samaru, Zaria was made by use of INAA using the Nigerian Research Rector -1 The results show that the samples contain Al 6,644.33mg/kg, Ti 1,275mg/kg, Cr 6.7mg/kg, Br 8.67 mg/kg, Co 22.13mg/kg, Cs20.22 mg/kg, Sb 0.09 mg/kg, As 0.49 mg/kg. These fertilizers show appreciable concentrations of elements that are beneficial to plant growth. Therefore, they are suitable source of plant nutrition because of the beneficial elements found in them. They however, contain, heavy metals, the results were validated with data obtained from the simultaneous analysis of Coal fly ash, which is an internationally certified reference material.

KEYWORDS: INAA, naturally occurring fertilizers, NRR-1s, plant nutrients, safe source

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Corresponding Author: jjelisha57@yahoo.com

INTRODUCTION

The burden we put on the environment has effect on our health through contamination and pollution of our atmosphere, hydrosphere and soil. The management of pollution emanating from various human activities should be a problem of global concern for all humanity. Human activities such as mining, iron and steel manufacture, use of insecticides and pesticides and the application of fertilizers on our gardens and croplands have exacerbated the level of air, water and soil pollutions (Suciu *et al.*, 2001). Though Phosphate fertilizers are very important in sustaining soil fertility and productivity, they however, may contain heavy metals and naturally occurring radioactive materials obtained from Phosphate ore used in the production of phosphate fertilizers (Elisha and Elisha, 2014, Santos *et al.*, 1975). The use of chemical fertilizers may contaminate croplands with heavy metals and radionuclides, which may be carried- over from the processes of chemical fertilizer production (Elisha *et al.*, 2014). For the fertilization of croplands for the sustenance of farming activities, farmers should rely on activities that promote biological activities through land fallowing and manure amendments (Feller and Beare, 1997).This work determined the elements and their concentrations in organic fertilizers to ascertain the safety from heavy metals and richness in beneficial elements in organic fertilizers. Elemental analysis of fertilizers is necessary in order to ascertain the burden from heavy metals and radionuclide placed on our agricultural soils by use of phosphate fertilizers in particular (Elisha and Elisha 2014). The presence of heavy metals in the soil above their threshold levels may contaminate the environment and cause health problems to humans, plants and microorganisms (GRPC, 1977). Plants like all living organisms have cells within which numerous metabolic reactions responsible for growth and production take place. These reactions depend on chemical nutrients in the soil- which may contain heavy metals- to initiate and sustain these basic metabolic reactions (Mills & Jones, 1996). Heavy metals absorbed by plants and passed onto humans through the food chain may damage body

organs and tissues thus, constituting health problems (GRPC, 1977). For instance, Lead poisoning, which has effect on learning ability of children, also causes damage to kidney (Glover-Kervliet, 1995). It should be noted that, some of these elements that are beneficial to plants become contaminants when they exceed their threshold levels in soils. These elements are exemplified by Cu, Fe, Cr, Zn and Sb. This analysis determined the elemental composition of selected organic fertilizers by Instrumental Neutron Activation Analysis (INAA) using the Nigerian Research Reactor-1 (NIRR-1) installed at the Centre for Energy Research and Training, Ahmadu Bello University Zaria.

The NIRR-1 is a miniature Neutron source that has a tank in pool structural arrangement. INAA is a technique that determines large number of elements in different matrices (Munoz, *et al.*, 1993). The principle involves the n-gamma reaction which is the fundamental reaction for neutron activation analysis (Elkhangi, Abdalla, & Ahmed, 1994).The gamma rays emitted during the decay of the nucleus have specific energies that are characteristic for the nuclide in question. The probability of a neutron interacting with a nucleus is a function of the neutron energy. This probability is referred to as the capture cross-section, and each nuclide has its own neutron energy—capture cross-section relationship. For many nuclides, the capture cross-section is greatest for low energy neutrons (referred to as thermal neutrons). Some nuclides have greater capture cross-sections for higher energy neutrons (epithermal neutrons). For routine neutron activation analysis, the nuclides activated by thermal neutrons are what we look for. The activity for a particular radionuclide, at any time t during an irradiation, can be calculated from the following equation $A_t = \sigma_{act}\varphi N (1—e^{-\lambda t})$. Where A_t = the activity in number of decays per unit time, σ_{act}= the activation cross-section, φ = the neutron flux (usually given in number of neutrons $cm^{-2}\ s^{-1}$), N = the number of parent atoms, λ = the decay constant (number of decays per unit time), t = the irradiation time. From the above equation, we can see that the total activity for a particular nuclide is a function of the activation cross-section, the neutron flux, the number of parent atoms, and the irradiation time. The optimum irradiation time depends on the type of sample and the elements of interest (Ogunleye *et al.*, 2001). After the sample has been activated, the resulting gamma ray energies and intensities are determined using a solid-state detector (usually Germanium). Gamma rays passing through the detector generate free-electrons. The number of electrons (current) is related to the energy of the gamma ray. Given the differences in half-lives for various nuclides, there are optimum times to count an activated sample.

Table 1: Routine Irradiation and Measuring Regimes for NRR-1

Neutron flux/irradiation channel	Procedure	Tir	Td	Tc	Activation products
1×10^{11}n/cms/outer irradiation channel(B4,A2)	S1	2min	2-15min	10min	^{28}Al,^{27}Mg,^{38}Cl,^{49}Ca,^{66}Cu,^{51}Ti^{52}V,^{116m}In
	S2	2min	3-4h	10min	^{24}Na,^{42}K,^{165}Dy,^{56}Mm,^{152m}Eu,
5×10^{11}n/cms/inner irradiation channels(B1,B2,B3,L 2and A1)	L1	6h	4-5d	30min	^{239}Np(U),^{72}Ga,^{122}Sb
	L2	6h	10-15d	60min	^{46}Sc,^{141}Ce,^{60}Co,^{51}Cr,^{134}Cs,^{152}Eu,^{177}Lu,^{131}Ba,^{86}Rb,^{182}Tb,^{175}Yb,^{233}Pa(Th),^{65}Zn,^{59}Fe,^{181}Hf

Tir =Radiation time, Td= decay time, Tc= counting time, Source: Jonah *et al*. (2006)

Table 2: Nuclear Data and Limits for the Elements of Interest using Adopted Experimental Conditions

Target isotope	Product isotope by (n,γ) reaction	Half -life	Gamma-energy (KeV)	LOD(mg/kg)
^{23}Na	^{24}Na	14.96hr	1368.60	40(L1)
^{26}Mg	^{27}Mg	9.46min	1014.4	7250(S1)
^{27}Al	^{28}Al	2.24min	1778.99	17(S1)
^{37}Cl	^{38}Cl	37.24min	1624.7	2900(S1)
^{41}K	^{42}K	12.36hr	1524.58	2400(S2)
^{45}Sc	^{44}Sc	83.81d	889.28	0.2(L2)
^{48}Ca	^{48}Ca	8.72min	3084.54	6600(S1)
^{50}Ti	^{51}Ti	5.72min	329.08	2500(S1)
^{50}Cr	^{51}Cr	27.7d	320.98	23(L1)
^{51}V	^{52}V	3.75min	1434.08	15(S1)
^{55}Mn	^{56}Mn	2.58hr	846.76	0.9(S2)
^{58}Fe	^{59}Fe	44.5d	1099.25	829(L2)
^{59}Co	^{60}Co	5.27y	1173.2	3.0(L2)
^{65}Cu	^{66}Cu	5.10min	1039.2	172(S1)
^{64}Zn	^{65}Zn	243.9d	1115.55	120(L2)
^{71}Ga	^{72}Ga	14.1hr	834.1	1.0(L1)
^{75}As	^{76}As	26.32hr	559.10	1.2(L1)
^{81}Br	^{82}Br	35.3hr	776.5	3.0(L1)
^{85}Rb	^{86}Rb	18.8d	1076.60	3.0(L2)
^{115}In	^{116m}In	54.15min	1097.3	0.5(S1)
^{121}Sb	^{122}Sb	64.8hr	564.24	0.5(L2)
^{133}Cs	^{134}Cs	2.06y	795.85	1.7(L2)
^{130}Ba	^{131}Ba	11.8d	496.3	264(L2)
^{139}La	^{140}La	40.3hr	1596.21	0.2(L1)
^{140}Ce	^{141}Ce	32.5d	145.44	14(L2)
^{151}Eu	^{152}Eu	13.3y	1408.5	0.6(L2)
^{152}Sm	^{153}Sm	46.27hr	103.18	0.1(L10
^{159}Tb	^{160}Tb	72.3d	879.38	1.1(L2)
^{164}Dy	^{165}Dy	2.33hr	94.70	0.7(LS1)
^{174}Yb	^{175}Yb	4.19d	396.33	0.9(L1)
^{176}Lu	^{177}Lu	6.71d	208.36	0.1(L2)
^{180}Hf	^{181}Hf	42.4d	482.2	1.1(L2)
^{181}Ta	^{182}Ta	115d	1221.4	1.0(L2)
^{197}Au	^{198}Au	2.7d	411.8	0.02(L1)

Source: Jonah *et al.*, (2006)

MATERIALS AND METHOD

The organic fertilizer samples comprise two samples of cow dung (white Fulani- open-field herd and white Fulani-milk-shade herd), two Sheep dropping (labelled hay flock and one Sheep dropping labelled grazing flock) obtained from National Animal Production Research Institute (NAPRI) Shika and Mamuda's pen in Samaru, Zaria. Also they were two chicken litter (Layers litter Shika brown and Layers litter BZ farm) obtained from (NAPRI) Shika Zaria and from Abolude's poultry farm Area BZ ABU quarters Samaru, Zaria. These samples were transferred into polythene bags, labelled and taken to the Centre for Energy Research and Training laboratory, Ahmadu Bello University, Zaria for analysis using NIRR-1(Nigeria Research Rector -1).

The NIRR-1 is a Miniature Neutron Source Reactor (MNSR) and a low- power nuclear reactor that uses highly enriched Uranium as fuel, light water as moderator and Beryllium as reflector. The detection system consists of a horizontal dip-stick of High Purity Germanium (HPGe) with a relative efficiency of 10% at 1332.5 KeV gamma ray lines, MAESTRO emulation software compatible with the ADCAM ®Multi-Channel Analyzer (MCA) card and the associated electronic modules all made by EG & ORTEC interfaced with a Personal Computer. The efficiency curves of the detector system at near and far source detector geometries were determined by standard gamma –ray sources in the range(ce& co) of 59.5-2254KeV and extended to 4000KeV. The WINSPAN 2004 software for data processing and the gamma-ray spectral analysis was used (Liyu, 2004). The software requires a predetermination of calibration factors by a multi-element standard reference material for elements of interest using adopted irradiation and counting regimes as given in Table1 (Oladipo *et al.*,2012). Nuclear data and limits for the elements of interest using adopted experimental conditions are in Table 2.

The certified reference material IAEA-Coal fly ash was used to determine the calibration factors and to validate the procedure for all the elements in the fertilizer samples. The concentration of each element determined from this work using adopted procedures in Table 1 was compared with certified values shown on Table 2 and were within limits if detection.

For the determination of calibration factors, polyethylene films and rabbit capsules were soaked in 1.1 N $NHNO_3$ for 3days, washed with water and rinsed with de-ionized water.

Approximately 150 mg aliquots each of the standard and sample were weighed and wrapped in polyethylene films then placed in the rabbit capsules and fed into the reactor and irradiated using two schemes(long and short) based on their half-life. For elements whose irradiation may lead to short-lived activation products, the radiation of the samples is done in the outer irradiation channel B4 for 2minutes where the neutron energy is "soft"; this is done to eliminate errors that might arise from higher values of Mg in the presence of P. For samples leading to long –lived activation products the irradiation was performed for 6hrs in the inner channels where the thermal neutron flux is highest. Following the short-lived irradiation regime, the first count was performed for 10 minutes at position S1 after waiting for 2-15 minutes. Then the second counting was performed for 10 minutes at position S2 having waited for 3-4hrs. For the elements whose irradiation may lead to long-life, the first counting was performed for 30 minutes at position L1, after cooling off for 4-5 days, the second counting for 60 minutes at position L2 was performed after 10-15 days.

Table 3: Statistical comparison of elements in three types of organic fertilizers determined by INAA

Element	CRNL	CRND	CRNS	F-value	P-value
Mg	5352.00 ±4436.388a	2223.5 ±58.690a	2375.5 ±287.792a	0.944	0.481
Al	10094.5 ±9181.782a	3189 ±1503.309a	6795 ±4313.351a	0.681	0.571
Ca	42566 ±28660.452a	10731 ±1839.892a	10508.5 ±2465.681a	2.457	0.233
Ti	1906.5 ±697.914a	3600 ±1697.056a	414.5 ±586.192a	4.107	0.138
V	9.00 ±12.728a	0.00 ±0.000a	15.45 ±11.809a	1.199	0.414
Mn	227.20 ±0.283a	462.50 ±33.234a	282 ±132.936a	4.844	0.115
Dy	1.10 ±1.556	0.00 ±0.000a	0.60 ±0.849a	0.580	0.613
Na	2498.±182.434a	1305.5 ±1098.137a	1925 ±1885.147a	0.445	0.677
K	13634 ±2350.423a	33207 ±7797.974a	16176 ±11363.2a	3.477	0.165
As	0.75 ±0.064a	0.43 ±0.078a	0.53 ±0.382a	1.024	0.458
La	16.25 ±19.870a	6.64 ±1.082a	11.50 ±1.131a	0.349	0.731
Sm	2.34 ±2.786a	0.89 ±0.170a	1.73 ±0.445a	0.398	0.703
Unp_	1.05 ±1.485a	0.16 ±0.226a	0.57 ±0.113a	0.525	0.638
Sc	1.06 ±0.750a	0.64 ±0.078a	1.06 ±0.714a	0.331	0.741
Cr	71.21 ±90.098a	6.50 ±2.121a	8.45 ±3.606a	0.999	0.465
Fe	4024.3 ±5687.543a	2527 ±333.754a	4887 ±3077.3a	0.204	0.826
Co	67.80 ±92.207a	1.40 ±0.000a	1.55 ±0.495a	1.035	0.455
Zn	67.78 ±92.235a	53.00 ±4.243a	67.50 ±12.021a	0.049	0.953
Br	15.78 ±18.696a	8.10 ±1.980a	3.70 ±1.273a	0.632	0.590
Rb	14.65 ±20.294a	75.50 ±19.092a	47.00 ±28.284a	3.528	0.163
Sb	0.35 ±0.071a	0.00 ±0.000b	0.00 ±0.000b	49.000	0.005
Cs	67.70 ±95.177a	0.00 ±0.000a	0.00 ±0.000a	1.012	0.461
Ba	67.50 ±95.459a	214.50 ±10.607a	250±138.593a	1.976	0.284
Eu	0.18 ±0.247a	0.29 ±0.021a	0.40 ±0.049a	1.132	0.430
Yb	0.18 ±0.247a	0.65 ±0.099a	0.54 ±0.163a	3.779	0.151
Lu	0.55 ±0.778a	0.08 ±0.000a	0.10 ±0.049a	0.705	0.561
Hf	2.05 ±1.344a	1.70 ±0.566a	2.50 ±0.424a	0.419	0.691
Ta	1.89 ±1.577a	6.75 ±3.323a	4.95 ±2.758a	1.718	0.318
Th	0.39 ±0.544a	1.05 ±0.212a	2.15 ±0.778a	5.037	0.110

Key: CRNL =Chicken litter, CRND = Cow dung, CRNS= Sheep dropping

Note: means with same letters are not significantly different at the stated P- Values

RESULTS AND DISCUSSIONS

Table 4: Results showing Elemental Composition of Organic Fertilizers usingNIRR-1

S/N	Element	CRNL1	CRNL2	CRND3	CRND4	CRNS5	CRNS6
1	Mg(mg/kg)	8108±381	1834±381	2219±46	1811±371	2317±262	1821±351
2	Al(mg/kg)	3,563±39	16,570±17	4,236±16	2,068±58	9,757±88	3,672±73
3	Ca (mg/kg)	62820±12	21360±940	9339±91	10840±1192	8238±527	12240±12
4	Ti (mg/kg)	BDL	1275±138	BDL	BDL	728±101	BDL
5	V (mg/kg)	BDL	16±2.0	BDL	BDL	22.8±1.0	5.9±1.2
6	Mn(mg/kg)	226.9±0.5	226±1	437±2	483±3	375±1	186±2
7	Dy(mg/kg)	BDL	2±0.2	BDL	BDL	1.0±0.2	BDL
8	Na(mg/kg)	2575±52	2364±5	527±2	2051±31	3239±19	576±16
9	K(mg/kg)	11830±142	15100±196	38490±231	26450±1243	23620±591	7517±624
10	As(mg/kg)	0.72±0.07	0.6±0.1	0.30±0.07	0.4±0.08	0.7±0.1	0.2±0.06
11	La(mg/kg)	2.1±0.1	30.2±0.1	7.33±0.07	5.80±0.07	10.6±0.1	12.2±0.1
12	Sm(mg/kg)	0.36±0.01	4.29±0.02	1.0±0.01	0.7±0.07	2.02±0.02	1.40±0.01
13	U(Np)(mg/kg)	BDL	1.9±0.2	0.26±0.06	BDL	0.52±0.13	0.41±0.08
14	Sc(mg/kg)	0.51±0.02	1.56±0.03	0.67±0.02	0.56±0.02	1.54±0.02	0.53±0.02
15	Cr(mg/kg)	6.6±0.9	7.918±127	4.0±1.0	7±1	9.8±1.2	4.9±1.0
16	Fe(mg/kg)	7918±128	2.4±0.2	2209±82	2760±3	6938±125	2627±84
17	Co(mg/kg)	2.4±0.2	128±5	1.3±0.1	1.2±0.2	1.8±0.1	1.1±0.1
18	Zn(mg/kg)	128±5	2.50±0.06	47±3	53±3	72±4	56±3
19	Br(mg/kg)	2.5±0.06	26±3	9.4±0.1	6.6±0.1	4.5±0.1	2.7±0.1
20	Rb(mg/kg)	26±3	0.24±.06	86±3	59±3	64±3	24±3
21	Sb(mg/kg)	0.24±0.06	0.3±0.1	BDL	BDL	BDL	BDL
22	Cs(mg/kg)	0.3±0.1	121±14	BDL	BDL	BDL	BDL
23	Ba(mg/kg)	121±14	BDL	204±18	190±17	136±16	326±22
24	Eu(mg/kg)	BDL	0.28±0.07	0.23±0.07	0.23±0.04	0.38±0.05	0.32±0.04
25	Yb(mg/kg)	0.28±0.07	BDL	0.61±0.11	0.48±0.10	0.57±0.08	0.33±.09
26	Lu(mg/kg)	BDL	1.0±0.1	0.07±0.01	0.06±0.02	0.12±0.01	0.05±0.01
27	Hf(mg/kg)	1.0±0.1	2.9±0.1	2.0±0.1	1.2±0.1	2.7±0.1	2.1±.1
28	Ta(mg/kg)	2.9±0.1	0.70±±0.07	4.3±0.1	8.9±0.2	6.7±0.2	2.9±0.1
29	Th(mg/kg)	0.70±0.07	BDL	1.1±0.1	0.8±0.1	2.6±0.1	1.5±0.1

Key: CRNL1= Layers litter (Shika brown)
CRNL2= Layers litter (BZ farm)
CRND 3= Cow dung (open grazing herd)'
CRND4= Cow dung (milking herd non-grazing)
CRNS5=Sheep dropping (open grazing flock)
CRNS6= Sheep dropping (open hay flock)
Layers (Shika Brown) and layers (BZ farm) are chicken litter

From Table 4 layers litter (Shika brown and layers litter (BZ farm) and chicken litter have high Mg content at an average of 4917 ppm with the litter of birds reared by NAPRI having as high as 8108 ppm of Mg. The droppings from sheep have an average of 2,069 ppm Mg with higher value recorded by sheep kept by NAPRI. Cow dung has the lowest content of Mg averaging 2,015 ppm; again, cow dung of the milk shade cows of NAPRI have higher value than those that went out grazing. Organic fertilizers from animals that fed on hay had higher Mg values; this could be because of the uptake of Mg from chemical fertilization of the grass that made the hay. The high Mg values in the chicken litter could be contamination from feeds.

The Ca content of the layers litter Shika Brown from NAPRI Shika was 62820 ppm and it was 2 times the content in Abolude's farm. This could be deliberate addition through fortification of the feeds. The cow dung also contain high Ca content with cow dung from milking herd non- grazing having as high as 2219 ppm which is about 1½ times higher than in cow dung (open grazing herds). The concentration of Ca in NAPRI Shika sheep was 2317ppm, which is 1½ times the concentration in Mamuda's sheep pen.

The K content was highest in NAPRI cow dung of the milking cow shed at 38490 ppm and the dung of the cattle that went grazing was 26450 ppm. The NAPRI Shika chicken litter, the NAPRI sheep dropping, and the Mamuda's pen sheep droppings have appreciably high K quantities, which is good for plants nutrition.

The Na content of NAPRI sheep dropping was 3259 ppm, which is 5½ times the content of Mamuda's sheep pen droppings. The Na content of NAPRI Shika chicken litter was 2575ppm. The dung of the NAPRI cows that went grazing was 2051 ppm, which is about 3½ times higher than the content in the dung of milking cow shed. Na is necessary in fertilizers for osmotic pressure regulation and acid-base balance with Cl (Romheld and Marscher, 1991) Na is non- essential for plants but it maintains turgor in plants.

Ba concentration was highest in sheep dropping from Mamuda's sheep pen at 326 ppm while in cow dung generally it was approximately 200 ppm and in chicken litter is was less than 200 ppm.

Cs was detected in only Layers litter Shika brown at 0.3±0.1 mg/kg and in Layers litter BZ farm at 121±14 mg/kg. The other samples recorded BDL using NIRR-1 facilities. The presence of Cs in the fertilizers could be from the recent Fukushima accident.

Cobalt was detected in all the organic fertilizers at a mean concentration of 22.13 mg/kg and at a range of 1.1 mg/kg -128.4 mg/kg; the highest concentration was recorded in Layers litter Shika Brown fertilizer followed by Layers BZ farm at 2.4±0.2 mg/kg and 2.2±0.1 mg/kg respectively. The other fertilizers recorded Cobalt concentration >1.0 mg/kg. The recommended human health screening level is 660 mg/kg. The mean Cobalt concentration in the soil is 12 mg/kg, ranging from 0.1 – 70 mg/kg.

Arsenic is a toxic metal known to cause cancer in humans. Arsenic is released into the environment through anthropogenic activities such as mining. Background concentration in soils is 1 mg/kg to 40 mg/kg. The highest concentration was recorded for Layers litter Shika brown 0.72 mg/kg. Naturally occurring fertilizers recorded Arsenic concentration <1mg/kg. Arsenic is used as a growth promoter in poultry and pigs and in the preservation of wood. The concentration of Arsenic in feeds ranges from 10-50 mg/kg (ATSDR, 2007).

Antimony was detected in only two fertilizers, Layers litter BZ farm and in Layers litter Shika brown at concentrations of 0.24±0.06 mg/kg and 0.30±0.1mg/kg respectively. Antimony background concentration in soil is 0.3 mg/kg-8.6mg/kg (Alloway, 1990).

Chromium concentration ranged from 4.0- 7.95 mg/kg with a mean of 6.7mg/kg. Chromium is essential for carbohydrate metabolism in both plants and animals and even in human nutrition (Mertz, 1969). However, when the concentration in the soil is above threshold level chromium can be toxic and bio accumulates in both plants and animals. The concentration of Chromium in the soil ranges from 2-60 mg/kg (Kabata-Pendias and Pendias, 1984).

Micronutrients exemplified by iron vital for Nitrogen fixing and recognized as beneficial to the growth of plants and crops and to quality of soil. Iron aids respiration, and is a constituent of cytochrome and iron proteins involve in photosynthesis (Shaffer, 2001).

The fertilizer Litter Shika brown from NAPRI recorded the highest iron concentration of 7,918 mg/kg. The organic fertilizers were also rich in Boron. Boron is useful for carbohydrate movement within the plant (Cakmak 2002).

Zinc recorded a mean concentration of 59.75 mg/kg with highest concentration recorded by the fertilizer chicken litter at 128 mg/kg. Zinc maximum permissible concentration in foodstuff is 40-50mg/kg , and the concentration in uncultivated soil of North Guinea Savannah as 31.5 to 402 mg/kg (Lambert, Grant & Sauvé, 2007, Ogunyele *et al.*, 2001), the maximum concentration of zinc in the organic fertilizers falls within the values obtained in the soils of North Guinea Savannah (Munkholm, 1992).

Manganese is recognized as beneficial to plant growth and crops and to the quality of soil. The mean of 22.31mg/kg and a range of 186 mg/kg to 483 mg/kg were recorded by Cow dung (open grazing herd and Cow dung (milking herds non-grazing) respectively.

CONCLUSIONS

The analysis using the Nigerian Research Rector-1(NIRR-I) which is an INAA technique has successfully determined twenty-nine elements in the organic fertilizers. The elements determined include heavy metals like Cr, As, Co, Cs and Sb whose concentration when above threshold levels renders them toxic and dangerous to human health especially when ingested through the food chain. However, the concentrations of these elements in the organic fertilizers are within the concentrations in agricultural soils. This indicates that these fertilizers are safe for use as a source of plant nutrients.

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